

INVESTIGATION OF THE EFFECTIVE NN INTERACTION THROUGH $^{28}\text{Si}(\vec{p},\vec{p}')^{28}\text{Si}$ POLARIZATION TRANSFER

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The primary objective of Experiment E353 is the measurement of a complete set of polarization transfer observables for the two 6^- states in ^{28}Si at 11.58 MeV ($T=0$) and 14.36 MeV ($T=1$). Some linear combinations of the spin transfer observables are sensitive separately to spin-orbit and tensor terms in the effective interaction, while others may be used to measure phase relationships between the spin-orbit and tensor terms. The two 6^- states are "stretched" states, so they have a simple particle-hole structure. Inelastic electron scattering has been measured for the 6^- transition,¹ and fitting to the electron scattering form factor data serves to confirm the simple structure models of these transitions. Due to the large energy separation of the two 6^- states, the isospin mixing is small. This is confirmed by pion inelastic scattering,² so the isoscalar and isovector effective interaction components can be studied separately.

The optical model distortions needed for distorted-wave calculations are obtained from an analysis of $p + ^{28}\text{Si}$ elastic scattering reported in the previous Annual Report.³ The optical potential contains a complex spin-orbit term, and is consistent with the trends in Olmer, *et al.*⁴

The natural-parity transitions in ^{28}Si have been measured previously as part of a study of the effective interaction, giving rise to a parametrization of medium-modifications of the spin-independent isoscalar central and spin-orbit components.⁵ This medium modification, which is based on Pauli blocking corrections, is better for the low density transitions than for high density. The unnatural 6^- ($T=0$) and 6^- ($T=1$) high-spin transitions provide a good way to study the medium modifications of spin-dependent tensor and spin-orbit components in the effective nucleon-nucleon interaction since the dominant spin-independent central term t_0^C makes little contribution to them.

Data acquisition began in May, 1991. The first run, made with only a vertically polarized beam, included measurements of the differential cross section and analyzing power for elastic scattering and measurements of $D_{NN'}$ for excited states in ^{28}Si at laboratory angles of 29° , 35° , and 41° . The second run, which started in August, 1992, with both vertical and in-plane polarized beam, included measurements of $D_{NN'}$ at a laboratory angle of 23° and the polarization transfer coefficient combinations, D_σ and D_λ , at laboratory angles of 29° , 35° and 41° . These combinations are defined by

$$D_\sigma = D_{SS'}\cos\alpha + D_{SL'}\sin\alpha$$

$$D_\lambda = D_{LS'}\cos\alpha + D_{LL'}\sin\alpha,$$

where α is the spin precession angle in the K600 magnetic spectrometer. The dipole ratio of the K600 was adjusted to produce a value of α near 225° , which weights each term in the sums equally. In this way the two polarization transfer coefficients expected to be large for “stretched” transitions, $D_{SS'}$ and $D_{LL'}$, would be sampled with comparable statistics. Due to a trim coil short in the D sector in the Main Stage Cyclotron, the 23° in-plane measurement was not finished.

By adjusting the currents of the BL3 THETA and BL5 PHI superconducting solenoids, the in-plane scattering was measured with three different spin directions oriented about 60° apart. Beam line polarizations were monitored continuously with the two p+d polarimeters located in BL3 and BL5. The proton bombarding energy of 198.5 MeV was chosen to be close to that used in earlier studies of $^{16}\text{O}(\vec{p}, \vec{p}')^{16}\text{O}$ and $^{10}\text{B}(\vec{p}, \vec{p}')^{10}\text{B}$ so that results on the effective interaction could be compared among these nuclei. Particles were momentum analyzed with the K600 magnetic spectrometer, giving 45-keV energy resolution, and outgoing proton polarizations were measured with the focal plane polarimeter.

The data for the $6^-, T=1$ transition are shown in Fig. 1. DWBA calculations with the free Love-Franey t -matrix (dashed curve) can not fit the data, especially $D_{NN'}$. Calculations with the medium modifications of the nucleon-nucleon interaction based on Pauli blocking effects also do not reproduce the data. The calculations for the $^{16}\text{O}, 4^-$ transition⁶ and the $^{10}\text{B}, 3^+ \rightarrow 0^+$ transition⁷ suggest that the fit to $D_{NN'}$ gets better if the ρ mass is smaller. In this model, the ρ meson is assumed to couple only through the transverse operator $(\vec{\sigma}_1 \times \vec{q})(\vec{\sigma}_2 \times \vec{q})$.⁸ The change of ρ meson mass will change the central and tensor components of nucleon-nucleon interaction. So, we obtain a modified t -matrix, t' , with

$$t' = \alpha_0 t_0 + \alpha_1 \Delta t_1^T + \alpha_2 \Delta t_2^C$$

where t_0 is the density-dependent Bonn t -matrix, α_0, α_1 and α_2 are adjustable coefficients, and a linearly density-dependent Δt is calculated by

$$\Delta t = V_{NN}(m_\rho^*/m_\rho = 0.8) - V_{NN}(m_\rho^*/m_\rho = 1).$$

With the modified t -matrix, and values $\alpha_0 = 1.05$, $\alpha_1 = 2.20 + 1.06i$ and $\alpha_2 = 1.06 + 0.37i$, calculations of spin observables fit the data better, as seen by the solid curves in Fig. 1. However, errors on these coefficients remain large and differences between the real parts of α_1 and α_2 are probably not significant. It can be shown that the real ρ meson exchange has a spin-orbit component which is absent from our model, and the effects of the spin-orbit component with the change of ρ meson mass are significant. The preliminary in-plane measurements for ^{10}B from the recent E368 experiment⁹ show that no medium modification of the tensor interaction is required to fit D_σ and D_λ data. In order to understand these, further investigation is underway.

The measured $6^-, T=0$ transition coefficients are shown in Fig. 2. The measured $D_{NN'}$ value for the $6^-, T=0$ transition is close to 1. Though the $6^-, T=0$ transition strength is too small to be measured in inelastic electron scattering, we assume that it has the same nuclear structure as the $6^-, T=1$ state. DWBA calculations with the free Love-Franey t -matrix don't fit the data. The calculated value for $D_{NN'}$ lies far below the experiment data which is similar to the case of the $6^-, T=1, D_{NN'}$ calculation. The medium modification calculation of the $6^-, T=0$ transition is also underway.

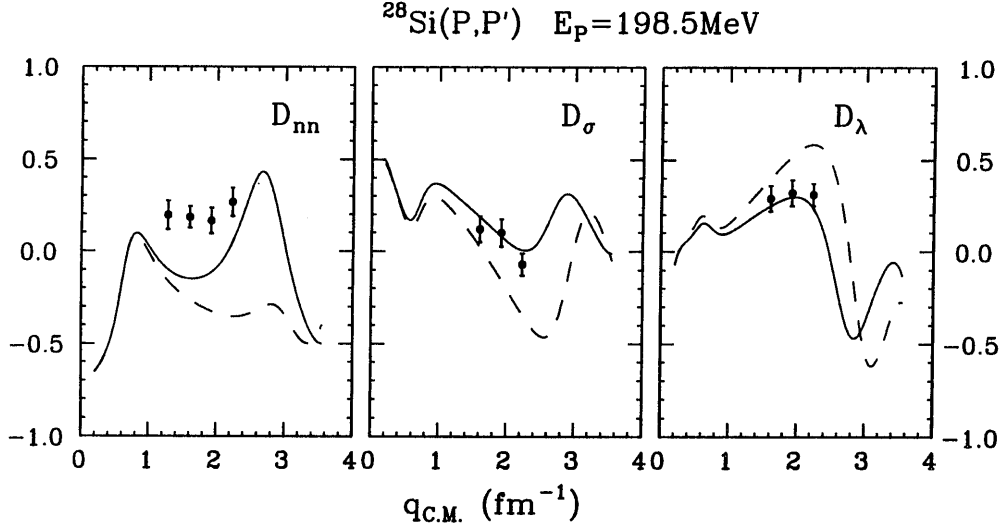


Figure 1. $^{28}\text{Si}(\vec{p},\vec{p}')^{28}\text{Si } 6^-, \Delta T=1$ transition data for $D_{NN'}$, D_σ , and D_λ . The solid curve is the DWBA calculation with a modified t -matrix and the dashed curve is the DWBA calculation with free Love-Franey t matrix.

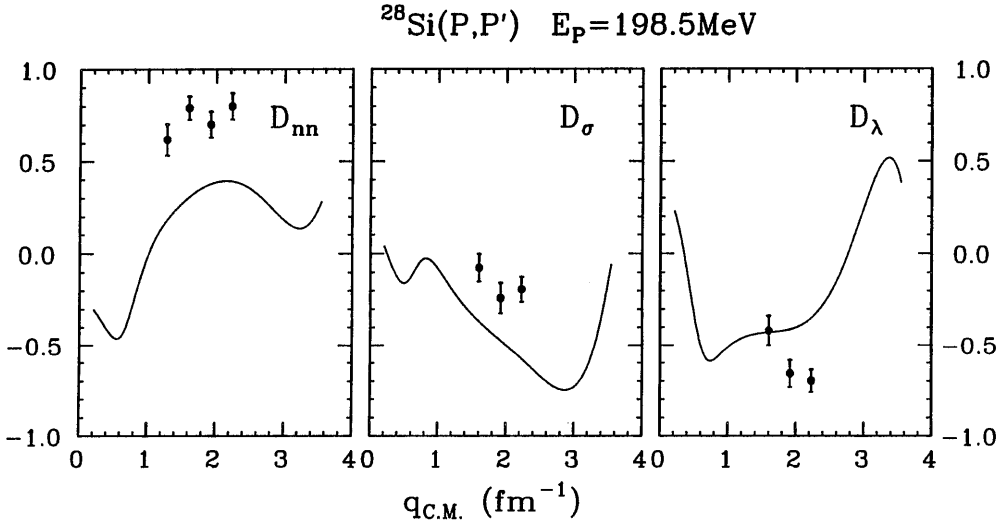


Figure 2. $^{28}\text{Si}(\vec{p},\vec{p}')^{28}\text{Si } 6^-, \Delta T=0$ transition data for $D_{NN'}$, D_σ , and D_λ with the DWBA calculation based on the free Love-Franey t -matrix.

1. S. Yen, R.J. Sobie, T.E. Drake, H. Zarek, C.F. Williamson, S. Kowalski, and C.P. Sargent, Phys. Rev. C **27**, 1939 (1983).
2. C. Olmer, B. Zeidman, D.F. Geesaman, T.-S.H. Lee, R.E. Segel, L.W. Swenson, R.L. Boudrie, G.S. Blanpied, H.A. Theissen, C.L. Morris, and R.E. Anderson, Phys. Rev. Lett. **43**, 612 (1979).
3. J. Liu, *et al.*, IUCF Sci. and Tech. Rep., May 1991 - April 1992, p. 17.
4. C. Olmer, A.D. Bacher, G.T. Emery, W.P. Jones, D.W. Miller, H. Nann, P. Schwandt, S. Yen, T.E. Drake, and R.J. Sobie, Phys. Rev. C **29**, 361 (1984).
5. Q. Chen, J.J. Kelly, P.P. Singh, M.C. Radhakrishna, W.P. Jones, and H. Nann, Phys. Rev. C **41**, 2514 (1990).
6. E.J. Stephenson and J.A. Tostevin, IUCF Sci. and Tech. Rep., May 1990 - April 1991, p. 29.
7. H. Baghaei, R.A. Lindgren, P. Slocum, E.J. Stephenson, A.D. Bacher, S. Chang, J. Lisantti, J. Liu, C. Olmer, S. Wells, and S.W. Wissink, Phys. Rev. Lett. **69**, 2054 (1992).
8. G.E. Brown and M. Rho, Phys. Lett. B **237**, 3 (1990).
9. S. Chang, *et al.*, this report.